


METHOD FOR THE STATISTICAL MULTIPLEXING OF ATM CONNECTIONS

5 Ins ^A  The invention is directed to a method according to the preamble of
A ~~patent claim 1.~~

A A ^{number} plurality of connection types ~~are defined~~ given connections via which information ^{is} ~~are~~ transmitted according to the asynchronous transfer mode (ATM). ^{are known connections} Thus, on the one hand, ~~connections~~ having strict demands made of the cell delay times are distinguished from connections that do not make strict demands of the cell delay times.

Particularly included among the former are connections with which information ^{is} ~~are~~ transmitted with a constant bit rate (CBR) as well as connections via which real time information ^{is} ~~are~~ transmitted with ^a ~~a~~ variable bit rate (rt-VBR).

15 The latter include non-real-time VBR connections (nrt-VBR) or
A connections via which information are transmitted with a variable bit rate
 (available bit rate, ABR) or unspecified bit rate connections (UBR).

The information of all five connection types ~~are~~ conducted in ATM cells ~~in common~~ via virtual paths or, respectively, virtual lines having a predetermined bit rate (bandwidth). In the course of ~~the setup of~~ ^{setting up} new connections that have strict demands made of the cell delay times, it is required to calculate the bandwidth ~~that is~~ required for the totality of all connections conducted over a connecting section/connecting line or a virtual path. For calculating an effective bandwidth, it is necessary to determine the rate with which the large cell memory offered for this connection type as well as the other connection types (nrt-VBR, ABR, UBR) is allowed to be emptied.

30 Upon setup of an ATM connection, the transmitting means must generally inform a higher-ranking control means (all acceptance control) of previously defined parameters. This is required in order to assure the quality

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A a calculation is already carried out at the call setup as to whether this new connection can be accepted in addition to the connections already existing.

When the transmission capacity has already been exhausted, the requested connection is rejected.

A defined on a connection. This is thereby a matter of an upper limit for the ^{number} ^{of} ATM cells that can be transmitted per second of this connection.

A during the existence of the connection. As further parameters, the ^{maximum} possible transmission capacity of the connecting line (link cell rate, C) as

connecting line, whereas the latter defines a quantity with which the maximally allowable aggregate cell rate on the connecting line is recited.

then made as to whether new connection requests can be accepted or not.

A ^{Sequence utilized} To this end, an algorithm sequences in the higher-ranking control

are checked. Further, these are compared to parameters that have already been calculated and relate to the momentary load on the connecting line.

A decision is then made on the basis of these comparisons as to whether the new connection request is accepted and this connection can still be

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permitted. Among other things, the peak cell rate that has already been addressed or the sustainable cell rate are employed as critical parameters.

A number of methods have developed in the prior art for handling these procedures. ^{The} Let the sigma rule algorithm ^{is an example of} be recited here as a simple method. This algorithm is disclosed in detail in German Patent Application DP 196 49 646.7. ^{An} A ⁿth connection is thereby only allowed when the following is valid for the (n - 1) connections already existing plus the nth connection:

$$(a) \quad \sum_{i=1}^n PCR_i \leq p_0 \cdot C$$

^{The following condition (b) is met}
A The connection is likewise allowed when, taking additional properties of the n connections into consideration, as ^{will be} explained later, the following condition (b) is met.

$$(b) \quad \sum_{VC_i \in \text{class S}} SCR_i + g(c, \text{class S}) \cdot \left(\sum_{VC_i \in \text{class S}} SCR_i \cdot (PCR_i - SCR_i) \right)^{1/2} \leq p_0 \cdot C - \sum_{VC_i \in \text{class P}} PCR_i$$

whereby $c = p_0 \cdot C - \sum PCR_i$ is the free capacity for class S.

It can be derived from condition (b) that the pending connections are divided into two classes here. At the beginning of the connection setup, ^{thus,} the sigma rule algorithm must make a decision as to which of two classes, namely a class S as well as a class P, the potentially newly added ATM connection is to be assigned to.

All virtual connections are assigned to class S for which a statistical multiplexing according to the sigma rule algorithm would yield a noticeable gain compared to the peak cell rate reservation algorithm. The following condition must be met as ^a criterion for this type of connection for the peak cell rate and the sustainable cell rate of all connections to be statistically multiplexed:

$$PCR/C < 0.03 \quad \text{and} \quad (0.1 \leq SCR/PCR \leq 0.5)$$

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4. ~~maximally possible transmission capacity of the connecting line is valid as~~
 criterion for this.

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[illegible]

A of the arrival of a new connection request, thus, the sigma rule algorithm must check based on the criterion of determined interrogation criteria to see which of the sub-classes this new connection is to be assigned to. The most beneficial sub-class S_x is then automatically selected. A sub-class S_x is thereby defined via a lower limit or, respectively, upper limit of the peak cell rate PCR as well as of the relationship of the transmission parameters SCR/PCR.

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A Equation (b) thus experiences a modification, as shown in Equation (c), by the addressed sub-classes S_k, P_k

$$(c) \quad \sum_{VC_i \in S_k} SCR_i + q(c, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i \cdot (PCR_i - SCR_i)} \leq c$$

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whereby $c = p_0 \cdot C - \sum_{VC_i \in P_k} PCR_i$ is the free capacity for the class S.

A The q factor thus derives as $q(c, S_k) = q1_{S_k} + q2_{S_k} / c$

This connection acceptance algorithm according to this prior art is

A thus in the position of deciding whether a predetermined bandwidth, for (c.g.,

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A example the bandwidth of a virtual path or of a line, is adequate overall for a group of connections. Since such acceptance algorithms supply a

A yes/no decision as a result as to whether a connection is to be accepted or not,

A or not, they are not directly suited for the calculation of the effective bandwidth for a group of connections.

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The effective bandwidth required for a group of connections according to the used sigma rule acceptance algorithm could fundamentally be determined with arbitrary precision by an iterative approximation method. The problem of this method, however, is

A comprised therein that the acceptance algorithm would have to be

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A multiply run per connection setup and, thus, would require an extremely great amount of processor capacity.

European Patent Application EP 0 673 138 A2 discloses a method of how a plurality of connections can be conducted over a common

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~~In>~~ ~~Proceeding on the basis of the features recited in the preamble of~~
~~patent claim 1, the invention is achieved by the features of the characterizing-~~
~~part.~~

~~A~~ What is particularly advantageous ⁱⁿ for the invention is that the sigma
 5 ~~A~~ rule algorithm is employed as ^{an} acceptance algorithm. The bandwidth,
~~A~~ proceeding from an initial value, is determined step-by-step with the
 setup/release of connections. The sigma rule algorithm is started at every
 step and, in addition to supplying a yes/no decision, supplies an estimate of
 10 ~~A~~ the bandwidth based on the prescription of acceptance ^{criteria and a} ~~criteria, a~~
 conservative traffic parameter value of a class-specific bandwidth is added
~~A~~ or, ~~respectively,~~ subtracted. The conservative traffic parameter value is
 thereby constructed differently in the case of the connection setup than in
 the case of the connection release. When the sigma rule algorithm
 15 determines that the conservative estimate with respect to the bandwidth
 would be adequate, then a more aggressive traffic parameter value is added
~~A~~ to or, ~~respectively,~~ subtracted from the class-specific bandwidth. Here, too,
 the more aggressive traffic parameter value is fashioned differently in the
 case of the connection setup than in the case of the connection release.

~~In>~~ ~~Advantageous developments of the invention are recited in the~~
 20 ~~subclaims.~~

~~The invention is explained in greater detail below with reference to an~~
~~exemplary embodiment.~~

Shown are:

~~Fig. 1~~ ~~a flow chart according to the inventive method;~~

~~Fig. 2~~ ~~a flow chart according to the inventive method.~~

~~Fig. 1 shows a flow chart of the inventive method. The initially~~
~~described sigma rule algorithm SR of the prior art is employed as~~
~~acceptance algorithm. In accord therewith, additional status variables are~~
~~introduced in addition to the status variable carried in the sigma rule~~
 30 ~~algorithm SR. What are thereby involved are a matter of the status variables~~
 ~~c_{K1}^S , c_K^P and c_K^{eff} .~~

- A The status ^{variable} c_k^S is a matter of the effective bandwidth of the virtual connections that are to be assigned to one of the classes S_k according to the sigma rule algorithm SR. The status ^{variable} c_k^P indicates the sum of the peak cell rates PCR of all virtual connections in the class P_k , whereas the status ^{variable} c_k^{eff} is defined as effective bandwidth of all connections with reference to the classes k . ^{The relationship that} What thus follows is:

$$(1) \quad c_k^{\text{eff}} = c_k^S + c_k^P$$

- Given $(n-1)$ existing connections VC_i with the parameters PCR_i , SCR_i , a calculation is then carried out for a connection setup to see whether 1) the new connection VC_n can be accepted or not; 2) the effective bandwidth c_k^{eff} that ^{is} are to be reserved for the $(n-1)$ existing connections VC_i including the newly added connection VC_n .

- In a first step, a check is first carried to see whether the new connection VC_n to be potentially accepted can be assigned to one of the classes S_k or P_k . For example, let it be assumed that this can be assigned to one of the classes S_k . In this case, a check is carried out to see whether the following condition is met for all virtual connections VC_i , including the connection to be potentially added:

$$(2) \quad \sum_{VC_i \in S_k} SCR_i + q(c^{S_k} + SCR_n, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i \cdot (PCR_i - SCR_i)} \leq c^{S_k} + SCR_n$$

- In the above equation, Equation (c) is taken as the basis and the variable c employed therein is replaced by the bandwidth c_k^S reserved for the $(n-1)$ connections plus the average sustainable cell rate SCR_n that is to be reserved for the n^{th} connection VC_n to be potentially accepted. As can be seen according to Fig. 1, the method is started with a value $c_k^S = 0$.

- A strict application of condition (2) likewise yields a bandwidth that is greater than the sum of the peak cell rate PCR_n of all connections. Since the sum of all added, effective bandwidths, however, is never allowed to lie above the sum of its peak cell rates PCR_n , condition (2) is modified in such a way that

$$(3) \min \left[\sum_{VC \in S_k} SCR_i + q(c^{S_k} + SCR_n, S_k) \cdot \sqrt{\sum_{VC \in S_k} SCR_i \cdot (PCR_i - SCR_i)}, \sum_{VC \in S_k} PCR_i \right]$$

$$c_k^S + SCR_n$$

Thus, reliability in the estimate is established

A is taken. ~~A security in the estimate is thus established.~~

When the above condition applies, then the effective bandwidth

5 A employed up to ~~then~~ ^{that point} plus the sustainable cell rate SCR_n allowed for the n^{th}
 A connection VC_n is taken as ~~new~~ ^{the new} effective bandwidth c_k^S . As a result thereof,
 A the following ~~derives~~ ^{condition applies}:

$$(4) \quad c_k^{S_k} = c^{S_k} + SCR_n$$

10 A When the condition (3) is not met, the effective bandwidth employed up to
 A ~~then~~ ^{that point} plus the peak cell rate PCR_n allowed for the n^{th} connection VC_n is taken
 A ~~as new~~ ^{the new} effective bandwidth c_k^S . *Accordingly, the following condition applies:*

$$(5) \quad c_k^{S_k} = c^{S_k} + PCR_n$$

15 When the new connection VC_n to be potentially added is to be allocated to one of the classes S_k , a value for the effective bandwidth c_k^{eff} has thus been found.

When the new connection VC_n to be potentially added cannot be assigned to one of the classes S_k , it is automatically assumed that it is to be allocated to one of the classes P_k . The following thus derives:

$$(6) \quad c_k^{P_k} = c^{P_k} + PCR_n$$

20 Upon employment of Equation (1), the effective bandwidth c_k^{eff} can then be
 A calculated: ^{as follows}

$$C^{eff_k} = C^{S_k} + C^{P_k}$$

An effective bandwidth has thus been found for the case of a connection setup.

Subsequently, it then must also be determined whether the new connection VC_n can be accepted. To this end, the condition

$$C^{eff_k} \leq PO \cdot C$$

5 must be met.

It is assumed below according to Fig. 1 that a connection release is to be implemented. It is thereby assumed that a connection VC_n is released given n existing connections VC_i having the parameters PCR_i , SCR_i .

10 A Given release of the connection, a check is first carried out to see whether this ^{pertain.ing} ~~appertain.ing~~ connection VC_n was allocated to one of the classes S_k . In this case, an interrogation criterion is applied to all remaining virtual connections VC_i (accept the connection VC_n) according to condition (7):

$$(7) \quad \sum_{VC_i \in S_k} SCR_i + q(c^{S_k} - PCR_n, S_k) \cdot \sqrt{\sum_{VC_i \in S_k} SCR_i \cdot (PCR_i - SCR_i)} \leq c^{S_k} - PCR_n$$

15 A strict application of condition (7) now potentially yields a bandwidth for the remaining $(n-1)$ connections that is greater than the sum of the peak cell rates of the connections. Condition (7) is therefore to be modified in such a way that

$$(8) \min \left[\sum_{VC_n, S_k} SCR_i + q(c^S - PCR_n, S_k) \sqrt{\sum_{VC_n, S_k} SCR_i (PCR_i - SCR_i)}, \sum_{VC_n, S_k} PCR_i \right]$$

$$\leq c^S - PCR_n$$

derives.

A When the above condition applies, then the effective bandwidth applied up to ~~then~~ ^{this point} minus the peak cell rate PCR_n allowed for the n^{th} connection VC_n is taken as ~~new~~ effective bandwidth c_k^S . Deriving therefrom is:

$$(9) \quad c_k^S = c^S - PCR_n$$

When condition (8) is not met, ~~then~~ ^{this point} the effective bandwidth employed up to ~~then~~ ^{then} minus the sustainable cell rate SCR_n for the n^{th} connection VC_n is taken ~~as~~ ^{as} new effective bandwidth c_k^S .

$$(10) \quad c_k^S = c^S - SCR_n$$

A value for the effective bandwidth c_k^{eff} has been found for the released connection VC_n that was allocated to one of the classes S_k .

When the released connection VC_n was not allocated to one of the classes S_k , it is automatically assumed that it was allocated to one of the classes P_k . The following thus derives:

$$(11) \quad c_k^P = c^P - PCR_n$$

Upon application of Equation (1), the effective bandwidth c_k^{eff} can then be calculated:

$$c_k^{eff} = c_k^S + c_k^P$$

A In one development of the invention, it is provided to replace Equation (10) with ^{embodiment} ~~can be replaced with~~ !

$$(1.2) \quad c^{S_1} = \min \left[c^{S_1} - \text{SCR}_n, \sum_{VC, S_1} \text{PCR}_i \right]$$

5 Upon release of connections that were allocated to one of the classes S_k , the value of the class-specific bandwidth c_k^s is thus upwardly limited by the sum of the peak cell rate of all connections allocated to the classes S_k . The corresponding conditions are shown in Fig. 2

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